Army Research Laboratory

Portable Weather Intelligence for the Soldier

by David Sauter

ARL-TR-4502 **July 2008**

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Army Research Laboratory
White Sands Missile Range, NM 88002-5501

ARL-TR-4502 **July 2008**

Portable Weather Intelligence for the Soldier

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*: July 2008	**2. REPORT TYPE**: Final
3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE: Portable Weather Intelligence for the Soldier	**5a. CONTRACT NUMBER**
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S): David Sauter	**5d. PROJECT NUMBER**
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES): U.S. Army Research Laboratory Computational and Information Sciences Directorate Battlefield Environment Division (ATTN: AMSRD ARL CI EM) White Sands Missile Range, NM 88002-5501	**8. PERFORMING ORGANIZATION REPORT NUMBER**: ARL-TR-4502
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Enhancements in computer hardware and software technology have allowed the development and porting of advanced environmental effects applications on highly portable lightweight computing devices. The U.S Army Research Laboratory's (ARL) Battlefield Environment Division has developed a number of such products on a personal digital assistant (PDA) for use by individual Soldiers. This technology includes a mobile heat stress calculator, an Artillery meteorological messages application (fielded in fiscal year 2007 (FY07) on the multi-service Centaur PDA), a weather alert, a rules-based weather effects application, and others. Each is discussed in detail.

15. SUBJECT TERMS

Weather Intelligence; Personal Digital Assistant; Mobile Computing Device

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			David Sauter
U	U	U	UU	24	**19b. TELEPHONE NUMBER** (*Include area code*): (575) 678-2078

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Acknowledgments

The author would like to acknowledge Terry Jameson of the U.S. Army Research Laboratory for his contribution to the mobile Artillery meteorological application referenced herein.

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Summary

Weather affects personnel, military operations, and weapon systems at all echelons, down to the individual Soldier level. Knowing what these effects are, as well as when and where they will occur (and if they will affect the enemy to the same extent), can provide the tactical commander with critical intelligence in both the planning and execution phases of a mission. By leveraging ongoing advances in information technology related to tactical networking, communications, and computers (both hardware and software), these weather intelligence products (decision aids, alerts, map overlays, etc.) can be made available to the lowest echelons. Client server computing (e.g., Web services and Java remote method invocation), the Java computing environment, and wireless communications are some of the pervasive Net centric technologies that will be utilized in the development and demonstration of the portable weather intelligence capability. This capability will contribute to weather related information sharing and enhanced situational awareness at the lower echelons. Mobile computing devices (HP 5500 and Toshiba e800 personal digital assistants) have been used as the host development and test hardware platforms.

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1. Introduction

Weather can and does impact nearly all military operations and weapon systems. The slowdown in the advance on Baghdad in the spring of 2003 due to severe dust storms is but one example. Sometimes these impacts are minor inconveniences, while other instances result in military casualties (*1*) and/or losses of equipment. Numerous field manuals, technical manuals, and documents (*2–4*) have been published with specific information regarding environmental impacts on operations and systems. The Army has fielded a tactical command and control system, the Integrated Meteorological System (IMETS)[*], at brigade and above echelons to provide weather and weather effects information to tactical units. However, there currently does not exist any IMETS-like functionality for the lowest echelons. Recent advances in computer hardware and software, along with Net-centric related information technology, are now providing the means to develop and demonstrate weather intelligence (decision aids, alerts via subscription services, map overlays, data, etc.) on a mobile computing device. A number of these intelligence products have been developed and demonstrated on a personal digital assistant (PDA).

2. Computing Environment

2.1 Mobile Device

The current mobile devices on which the weather intelligence applications have been hosted include a Hewlett Packard (HP) 5550 and a Toshiba e800 PDA. The features of the Toshiba device are numerous and fairly impressive considering the size and weight:

- 400 MHz Intel® processor
- 128 MB Synchronous Dynamic Random Access Memory (SDRAM)
- 4.0 in. 240×320 color display (480×640 with optional Resfix software)
- Integrated Wireless Fidelity (Wi-Fi) (Institute of Electrical Electronics Engineers (IEEE) 802.11b) wireless communications (comms)
- Integrated Secure Digital (SD) and Type I/II Compact Flash (CF) slots
- Integrated speaker and microphone
- Infrared (IR) port

[*]IMETS functionality is being transitioned to the Distributed Common Ground System Army (DCGS-A) Weather.

- 5.3 in. by 3.0 in. by 0.6 in. dimensions
- 6.8 oz weight

The CF capability allows for expanded functionality, if required, such as a Global Positioning System (GPS) card, additional program/application storage, etc. Optional software that has been loaded includes the CrEme™ Java virtual machine and the 100% pure Java PointBase® relational database. Additionally, C programming language source code can be compiled specifically for the PDA processor and operating system (Microsoft® Windows® Mobile 2003) using the Microsoft eMbedded Visual C++ environment. In this manner, both Java and C programs can be executed on the PDA. Using the Java Native Interface (JNI), C functions compiled as dynamic link libraries (dlls) can be called directly from within Java programs. The 480×640 display capability is valuable for the display of program Graphical User Interfaces (GUIs) requiring numerous inputs and/or outputs, although care must be taken in the selection of font size.

2.2 Portability Issues

Experience with the hosting of the existing weather intelligence applications from one PDA to another has been encouraging and it should be straightforward to port them to current or future fielded military mobile devices (the commercial wireless comms reliance may have to be replaced with tactical wireless comms protocols, such as used by the Joint Tactical Radio System or other deployed capability). Proof of this is evidenced in the transition of a mobile Artillery meteorological (Met) application to the fielded multi-service (Army and Marines) Centaur system. Centaur provides a backup capability to compute artillery Met messages on a mobile device (in this case, a ruggedized HP 5550 PDA for tactical deployment) and then use these messages to compute aiming corrections for artillery guns to insure more accurate firings. The initial software was developed on a non-tactical HP PDA in C++ and then delivered as a "cab" file for automated installation on the Centaur devices (see section 3.1 for details of the Artillery Met application). Reliance on the Java computing architecture (both the programming language and the PointBase relational database) also has been a contributing factor in the portability ease. More than one of the Java applications has run without a hitch on multiple platforms (e.g., a Windows 2000 laptop, a Compaq and Toshiba PDA, and even a Solaris workstation) using the same compiled class files.

3. Applications

All of the applications described in this section have been developed and demonstrated on either the Toshiba or HP PDA.

3.1 Mobile Artillery Met Messages

Met conditions both at the surface and aloft can significantly alter the intended trajectory of an artillery round. Furthermore, knowledge of the atmospheric conditions can be used to mitigate the adverse atmospheric effects. In mitigating these effects, artillery units compute and utilize coded messages (a Met computer (METCM) and Met ballistic (METB) message) to store, display, and transmit Met information on the battlefield. In late 2004, the U.S. Marine Corps (USMC) contacted the U.S. Army Research Laboratory's (ARL) Battlefield Environment (BE) Division to request assistance in the developing of a backup artillery Met capability on a tactical PDA, a ruggedized HP 5550 (figure 1), that would compute, display, and save both METCM and METB messages. Winds aloft are computed by the ARL implemented software (written in C++) automatically after the user enters the azimuth and elevation angles of a visually tracked pilot balloon (PIBAL) at various times during its ascent (figure 2). The METCM and METB are then used as input to other software resident on the PDA to compute the aiming corrections for the artillery guns. This software has been fielded on the Centaur system and is currently being trained by the USMC artillery unit at Ft. Sill, OK. For a detailed technical discussion of this application, see ARL-TN-244 (*5*).

Figure 1. Ruggedized PDA.

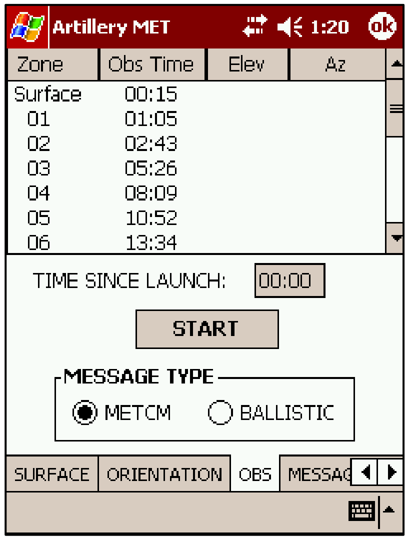

Figure 2. PIBAL entry screen.

3.2 Integrated Weather Effects Decision Aid (IWEDA)

IWEDA was initially developed for and fielded on the IMETS. It provides graphical and text information regarding weather impacts on hundreds of friendly and threat assets over space (generally a 500×500 km area of interest) and time (36–48 h forecast). Figure 3 provides an example of the temporal matrix for several weapon systems while figure 4 is a screen capture of the spatial distribution of impacts for a specific time and asset (in both figures, green represents no adverse impact, amber is a marginal impact, and red is an unfavorable impact). The capability to compare weather impacts on both friendly and threat items is a powerful tool for both mission planning and execution. As a Web browser version had been developed prior to the mobile platform effort, it was straightforward to implement this capability on the PDA using the integrated wireless communications. However, to eliminate the wireless communications dependence, a second version was developed that queries a weather effects relational database hosted on the PDA using the PointBase relational database. This standalone Java application simply needs to have the effects database downloaded once and then synchronized on a regular basis (the effects database is currently updated every 12 h). The ultimate objective is to have the effects database computed directly on the PDA (discussed later). Due to limited mapping and overlay capabilities on the PDA, only a non-dynamic overlay can currently be provided on the mobile device (the IMETS overlay is dynamic in that the user can click any point on the overlay for further information).

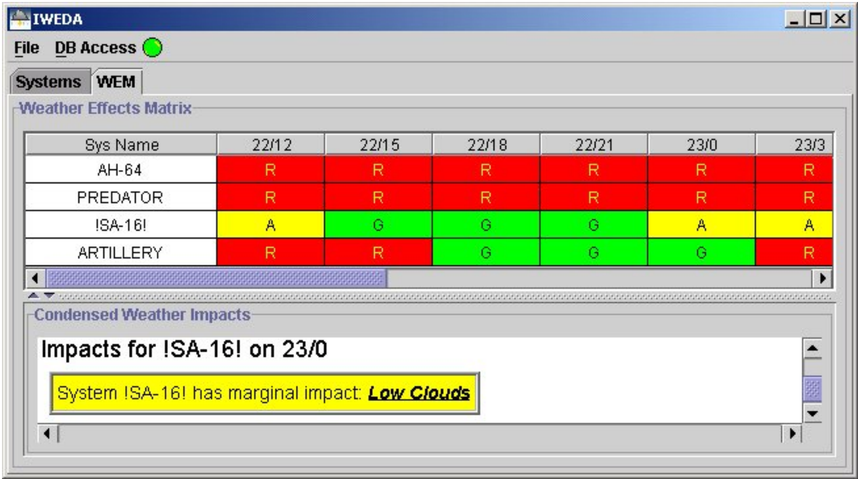

Figure 3. IWEDA temporal impacts.

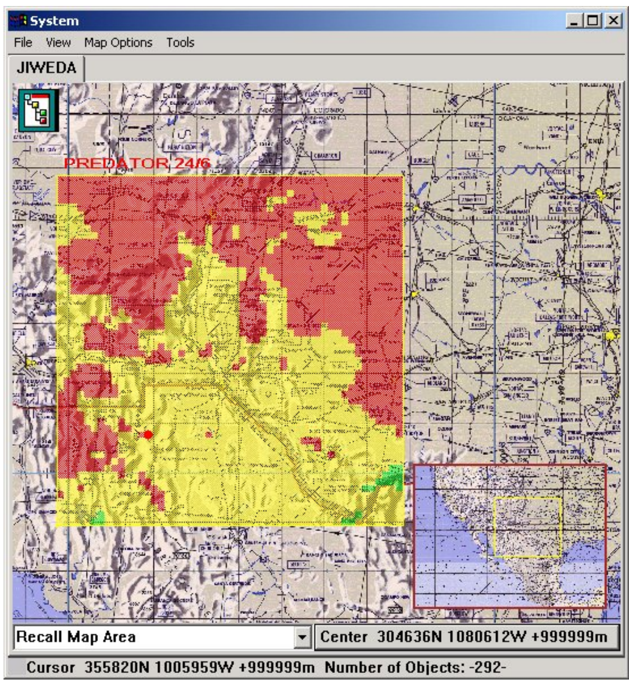

Figure 4. IWEDA spatial impacts.

3.3 Mobile Heat Stress

This decision aid leverages a research and development effort (*6*) by the U.S. Army Research Institute for Environmental Medicine (USARIEM) at Natick, MA. Existing algorithms as provided by USARIEM were recompiled for the mobile platform after removing a dependency on a black globe bulb temperature input, which would likely not be readily available on the mobile device. Instead, an algorithm already in use at ARL was incorporated to provide an estimate of the solar insolation value as a function of simple Met inputs (*7*). A Microsoft Foundation Classes (MFC) GUI was also developed to allow the user to enter the required inputs. If a GPS device is available on the PDA, the location information (latitude and longitude) is automatically entered for the user. The date and time inputs are likewise automatically obtained from the PDA calendar and clock. The outputs are a function of not only the Met, location, and time inputs, but also of the user-specified work rate and clothing level. Output consists of the probability of heat stress injury, the work/rest cycle, maximum work time, recommended consumption of canteens of water, and the Wet Bulb Globe Temperature. This application is completely standalone as all inputs are entered by the mobile user. Figures 5 and 6 show a sample input screen as well as the output screen.

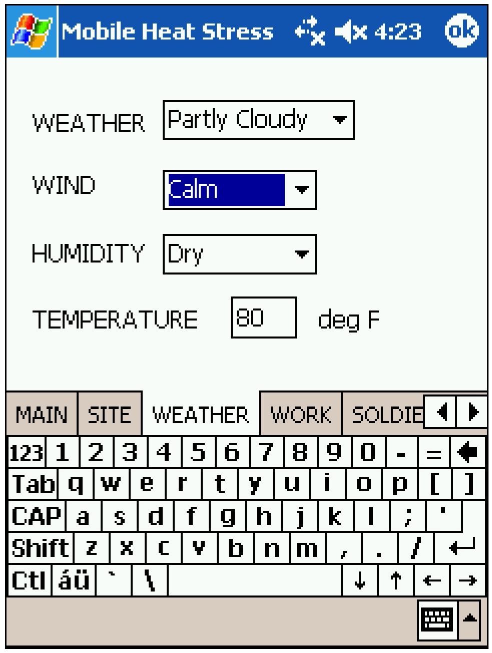

Figure 5. Weather inputs.

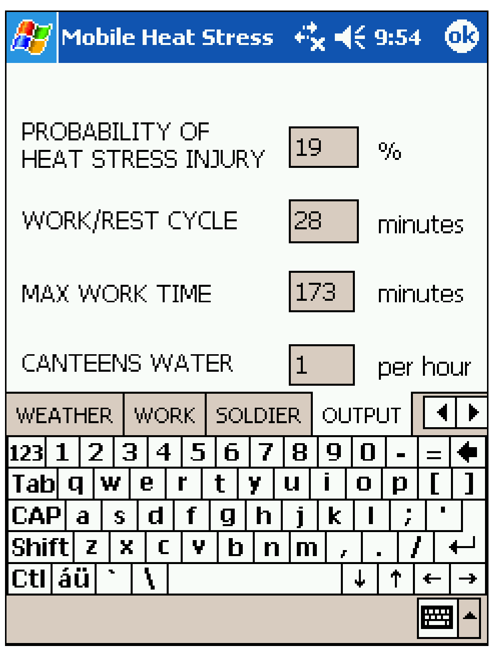

Figure 6. Output screen.

3.4 Weather Alert Subscription

This application allows the mobile user to subscribe to one or more weather related alerts (e.g., lightning, high winds, severe cold, etc.). Alert notification is made via a text message, with or without an audible alert (user specified). Java remote method invocation (rmi) servers are utilized on a laptop server and on the PDA to listen for subscriptions and notifications. The server software includes a GUI to specify the frequency that the alerts database should be queried as well as to display the number of clients currently subscribed. The client software GUI is displayed in figure 7. The client routine passes the alerts subscribed to as well as the client Internet Protocol (IP) address to the server via the commercial 802.11b wireless comms.

Figure 7. Weather alert.

3.5 Weather Observation Capability

This application provides the capability for the mobile user to enter and send a local weather observation back to a remote server. This is implemented as a Web service over the 802.11b wireless comms. Potential applications of the local data on a server include being used as initialization data for a prognostic Met model (as currently exists on the IMETS/DCGS-A Weather) or as input to a Chemical Biological Radiological (CBR) hazard dispersion model. It could also be used to populate a local dataset of mobile observations, which, in turn, could be used to create a local gridded Met database (see section 3.7). This gridded database could then be utilized as input for the PDA decision aids and alerts or in the display of weather conditions (e.g., streamlines or vectors of wind velocity, contours of air temperature, etc.) via map overlays. A simple Java GUI allows input of several meteorological parameters to include wind velocity, temperature, cloud conditions, and visibility (the list can be modified as necessary).

3.6 Mobile Acoustic Detection

Probability of detection of a user-specified acoustic target (e.g., tank, aircraft, etc.) by a specified sensor (e.g., microphone, human, etc.) is provided via a Java remote procedure call on a server. Acoustic propagation tables are computed a priori on the server as a function of existing or forecast weather and terrain conditions. This application is currently a prototype as there are only a limited number of targets and listening devices. There is also only a single static acoustic propagation table. Future enhancements could involve the dynamic creation of the propagation tables and an automatic computation (and display via graphics and text) of the probability of detection for target/sensor azimuths covering 360° (as opposed to a single user specified azimuth).

3.7 Gridded Met Database (GMDB)

As discussed briefly in section 3.5, an ultimate objective is to compute and store a GMDB directly on the PDA. This would, to a large extent, eliminate the requirement for wireless comms between the mobile device and a remote server, as the local GMDB could be queried as the source of Met inputs for the existing and planned mobile applications and could eventually be used as the input source for the computation and derivation of weather effects tables (e.g., acoustic propagation) and databases (the IWEDA effects database). Limited comms to a remote server would still be required to retrieve additional data as required for the initialization of the software to create the GMDB (e.g., a limited number of prognostic data gridpoints from a forecast weather model that includes upper atmospheric data that could not be directly measured or deduced by the mobile user). However, entire forecast grids would not be required for download. Once the remote data is obtained and supplemented with local observations, mathematical objective analysis routines can be run on the mobile device to compute and store the gridded Met information for analysis and very short forecast times. Initial coding and benchmarking has been done along these lines by creating uniform gridded fields on the PDA with simulated local surface weather observation data. Computation of 100 gridpoints for a single parameter (e.g., air temperature) takes less than 5 s on the Toshiba PDA (includes the writing of the output grid as a text file or as a binary large object (blob) in the PointBase relational database). These fields are only for surface parameters, however (i.e., 2 dimensional). The full capability as discussed in this section could be a few years off due to the relatively limited computing power of the mobile device.

4. Future Efforts

The development and demonstration of the technology as outlined in this report should be viewed as the first step in providing a truly pervasive Net-centric weather intelligence capability. Additional development and enhancement of the mobile weather intelligence suite of products is required to enable collaboration among independent applications. For example, the Java objects that form the core of the weather intelligence applications could be made available as Web services such that decision aids or applications that do not presently include weather effects have a means of incorporating them independently. Ultimately, the effects of the weather could be automatically included in mission planning and execution via dynamic background agents that do not require any human intervention (machine-to-machine capabilities). These agents would be able to determine and prioritize ongoing or planned military missions and then retrieve pertinent information to synthesize and present an integrated picture of all of the elements potentially affecting mission completion. Note that this information would need to include sources other than just weather, e.g., logistics, terrain, enemy, etc. This approach could be used at all echelons. However, just as importantly, much of the technology (as demonstrated by the fielded Artillery Met application) can be implemented individually as standalone applications. The Mobile Heat Stress decision aid is one such application.

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Acronyms and Abbreviations

ARL	U.S. Army Research Laboratory
BE	Battlefield Environment
blob	binary large object
CBR	Chemical Biological Radiological
CF	Compact Flash
comms	communications
DCGS-A	Distributed Common Ground System-Army
FY07	fiscal year 2007
GMDB	Gridded Met Database
GPS	Global Positioning System
GUI	Graphical User Interface
HP	Hewlett Packard
IEEE	Institute of Electrical Electronics Engineers
IMETS	Integrated Meteorological System
IP	Internet Protocol
IR	infrared
IWEDA	Integrated Weather Effects Decision Aid
JNI	Java Native Interface
Met	meteorological
METB	Met ballistic
METCM	Met computer
MFC	Microsoft Foundation Classes
MHz	megahertz
PDA	personal digital assistant

PIBAL	Pilot Balloon
rmi	remote method invocation
SD	Secure Digital
SDRAM	Synchronous Dynamic Random Access Memory
USARIEM	U.S. Army Research Institute of Environmental Medicine
USMC	U.S. Marine Corps
Wi-Fi	Wireless Fidelity

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